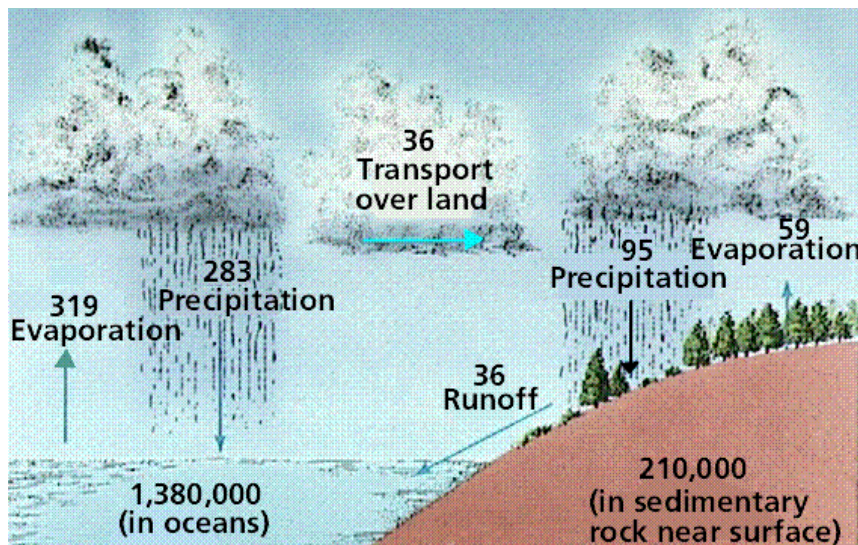


# Movement



Cell membranes act as barriers to most, but not all, molecules. Development of a cell membrane that could allow some materials to pass while constraining the movement of other molecules was a major step in the evolution of the cell. Cell membranes are differentially (or semi-) permeable barriers separating the inner

cellular environment from the outer cellular (or external) environment.

Water potential is the tendency of water to move from an area of higher concentration to one of lower concentration. Energy exists in two forms: potential and kinetic. Water molecules move according to differences in potential energy between where they are and where they are going. Gravity and pressure are two enabling forces for this movement. These forces also operate in the hydrologic (water) cycle. Remember in the hydrologic cycle that water runs downhill (likewise it falls from the sky, to get into the sky it must be acted on by the sun and evaporated, thus needing energy input to power the cycle).

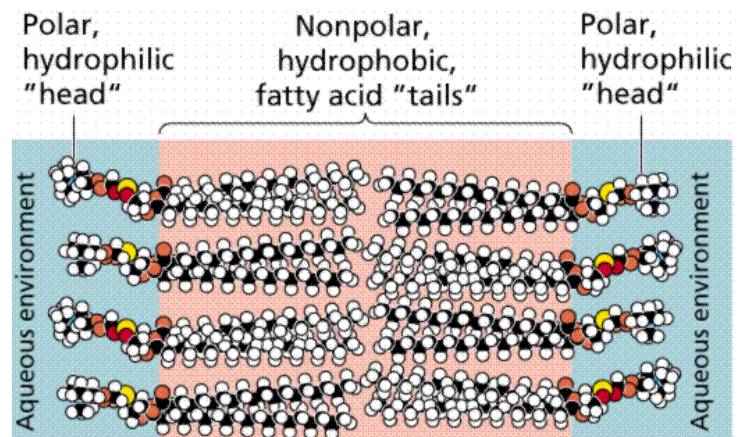
Diffusion is the net movement of a substance (liquid or gas) from an area of higher concentration to one of lower concentration. You are on a large (10 ft x 10 ft x 10 ft) elevator. An obnoxious individual with a lit cigar gets on at the third floor with the cigar still burning. You are also unfortunate enough to be in a very tall building and the person says "Hey we're both going to the 62nd floor!" Disliking smoke you move to the farthest corner you can. Eventually you are unable to escape the smoke! An example of diffusion in action. Nearer the source the concentration of a given substance increases. You probably experience this in class when someone arrives freshly doused in perfume or cologne, especially the cheap stuff.

Since the molecules of any substance (solid, liquid, or gas) are in motion when that substance is above absolute zero (0 degrees Kelvin or -273 degrees C), energy is available for movement of the molecules from a higher potential state to a lower potential state, just as in the case of the water discussed above. The majority of the molecules move from higher to lower concentration, although there will be some that move from low to high. The overall (or net) movement is thus from high to low concentration. Eventually, if no energy is input into the system the molecules will reach a state of equilibrium where they will be distributed equally throughout the system.

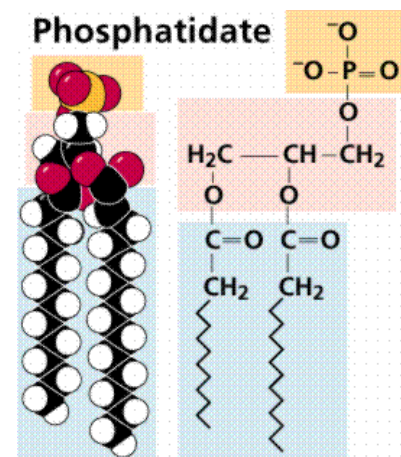
# The Cell Membrane

The cell membrane functions as a semi-permeable barrier, allowing a very few molecules across it while fencing the majority of organically produced chemicals inside the cell. Electron microscopic examinations of cell membranes have led to the development of the lipid bilayer model (also referred to as the [fluid-mosaic](#) model). The most common molecule in the model is the [phospholipid](#), which has a polar

([hydrophilic](#)) head and two nonpolar ([hydrophobic](#)) tails. These phospholipids are aligned tail to tail so the nonpolar areas form a hydrophobic region between the hydrophilic heads on the inner and outer surfaces of the membrane. This layering is termed a bilayer since an electron microscopic technique known as freeze-fracturing is able to split the bilayer.

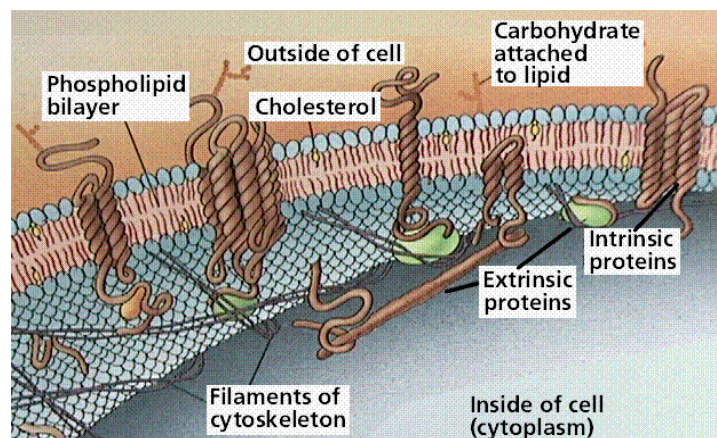


Phospholipids and glycolipids are important structural components of cell membranes. Phospholipids are modified so that a [phosphate group](#) ( $\text{PO}_4^-$ ) replaces one of the three fatty acids normally found on a lipid. The addition of this group makes a polar "head" and two nonpolar "tails".



Cholesterol is another important component of cell membranes embedded in the hydrophobic areas of the inner (tail-tail) region. Most bacterial cell membranes do not contain cholesterol.

Proteins are suspended in the inner layer, although the more hydrophilic areas of these proteins "stick out" into the cells interior as well as the outside of the cell. These integral proteins are sometimes known as gateway proteins. Proteins also function in cellular recognition, as binding sites for substances to be brought into the cell, through channels that will allow materials into the cell via a passive transport mechanism, and as gates that open and close to facilitate active transport of large molecules.



The outer surface of the membrane will tend to be rich in [glycolipids](#), which have their hydrophobic tails embedded in the hydrophobic region of the membrane and their heads



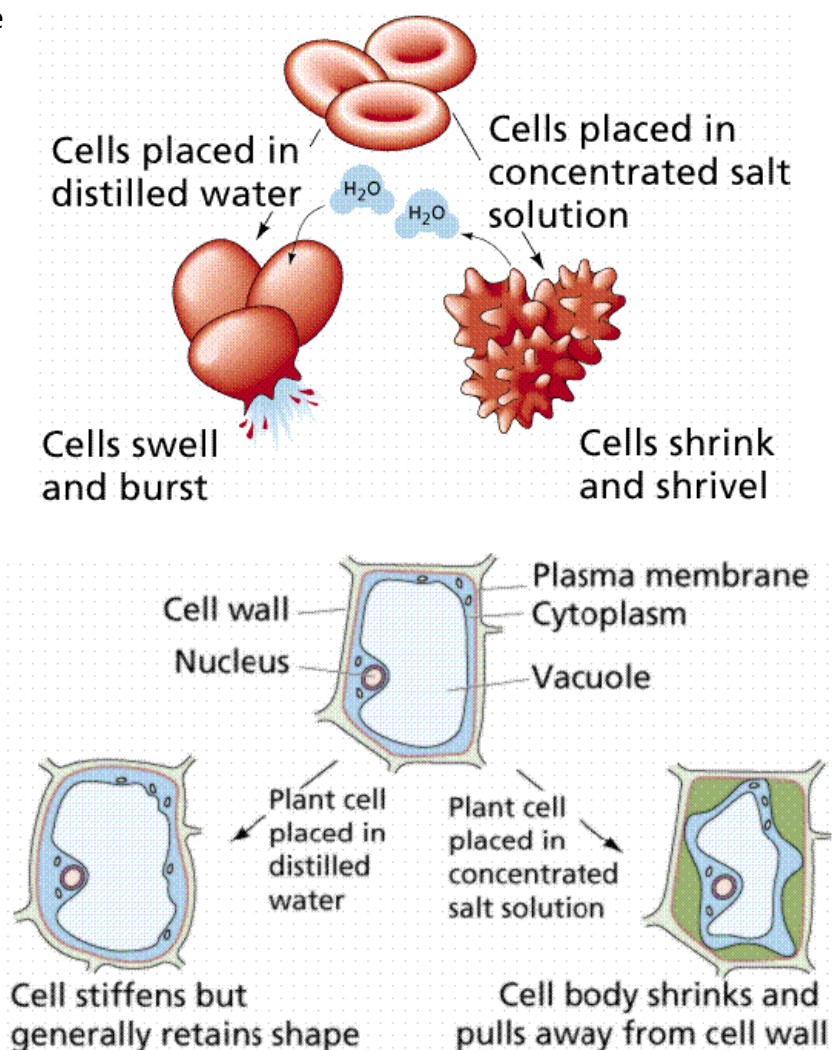
exposed outside the cell. These, along with carbohydrates attached to the integral proteins, are thought to function in the recognition of self. Multicellular organisms may have some mechanism to allow recognition of those cells that belong to the organism and those that are foreign. Many, but not all, animals have an [immune system](#) that serves this sentry function. When a cell does not display the chemical markers that say "Made in Mike", an immune system response may be triggered. This is the basis for immunity, allergies, and autoimmune diseases. Organ transplant recipients must have this response suppressed so the new organ will not be attacked by the immune system, which would cause rejection of the new organ. Allergies are in a sense an over reaction by the immune system. Autoimmune diseases, such as rheumatoid arthritis and systemic lupus erythmatosis, happen when for an as yet unknown reason, the immune system begins to attack certain cells and tissues in the body.

## Cells and Diffusion

Water, carbon dioxide, and oxygen are among the few simple molecules that can cross the cell membrane by diffusion (or a type of diffusion known as [osmosis](#)). Diffusion is one principle method of movement of substances within cells, as well as the method for essential small molecules to cross the cell membrane. Gas exchange in gills and lungs operates by this process. Carbon dioxide is produced by all cells as a result of cellular metabolic processes. Since the source is inside the cell, the concentration gradient is constantly being replenished/re-elevated, thus the net flow of  $\text{CO}_2$  is out of the cell. Metabolic processes in animals and plants usually require oxygen, which is in lower concentration inside the cell, thus the net flow of oxygen is into the cell.

Osmosis is the diffusion of water across a semi-permeable (or differentially permeable or selectively permeable) membrane. The cell membrane, along with such things as dialysis tubing and

cellulose acetate sausage casing, is such a membrane. The presence of a solute decreases the water potential of a substance. Thus there is more water per unit of volume in a glass of fresh-water than there is in an equivalent volume of sea-water. In a cell, which has so many organelles and other large molecules, the water flow is generally into the cell.



Animated image/movie illustrating osmosis (water is the red dots) and the selective permeability of a membrane (blue dashed line). Image from the Internet. Click on image to view movie.

Hypertonic solutions are those in which more solute (and hence lower water potential) is present. Hypotonic solutions are those with less solute (again read as higher water potential). Isotonic solutions have equal (iso-) concentrations of substances. Water potentials are thus equal, although there will still be equal amounts of water movement in and out of the cell, the net flow is zero.

One of the major functions of blood in animals is the maintain an isotonic internal environment. This eliminates the problems associated with water loss or excess water gain in or out of cells. Again we return to homeostasis. *Paramecium* and other single-celled freshwater organisms have difficulty since they are usually hypertonic relative to their outside environment. Thus water will tend to flow across the cell membrane, swelling the cell and eventually bursting it. Not good for any cell! The contractile vacuole is the *Paramecium*'s response to this problem. The pumping of water out of the cell by this method requires energy since the water is moving against the concentration gradient. Since ciliates (and many freshwater protozoans) are hypotonic, removal of water crossing the cell membrane by osmosis is a significant problem. One commonly employed mechanism is a contractile vacuole. Water is collected into the central ring of the vacuole and actively transported from the cell.

